



RHIC Retreat

May 24, 2022





RHIC through FY25

Michiko Minty

RHIC Retreat, 24 May 2022



@BrookhavenLab

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RHIC Run 22

run coordinator: Vincent Schoefer

RHIC Run-22 – last high energy $p\uparrow+p\uparrow$ run at RHIC

Run coordinator: Vincent Schoefer

Goals

$p\uparrow+p\uparrow$ polarized proton collisions at full energy (510 GeV com)
with new STAR forward detector upgrade

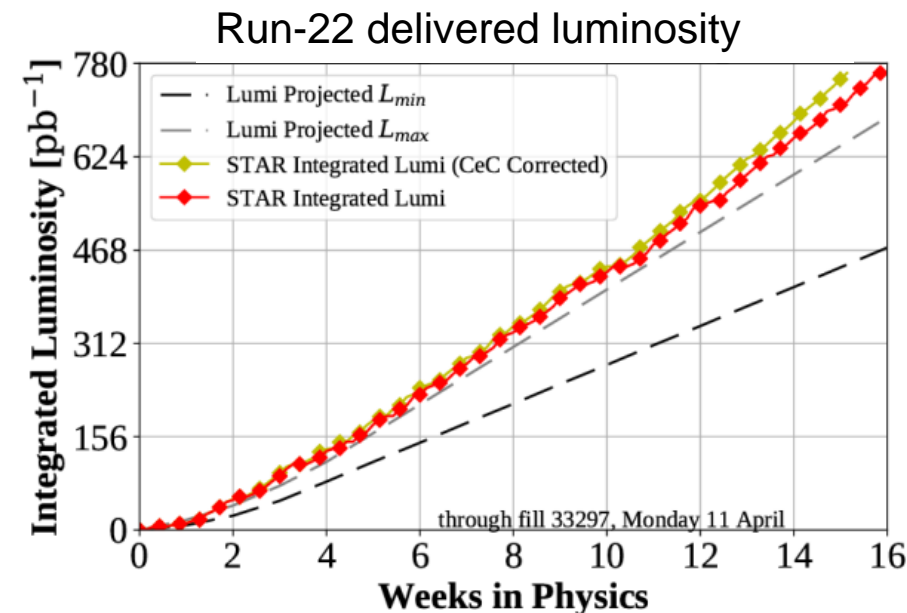
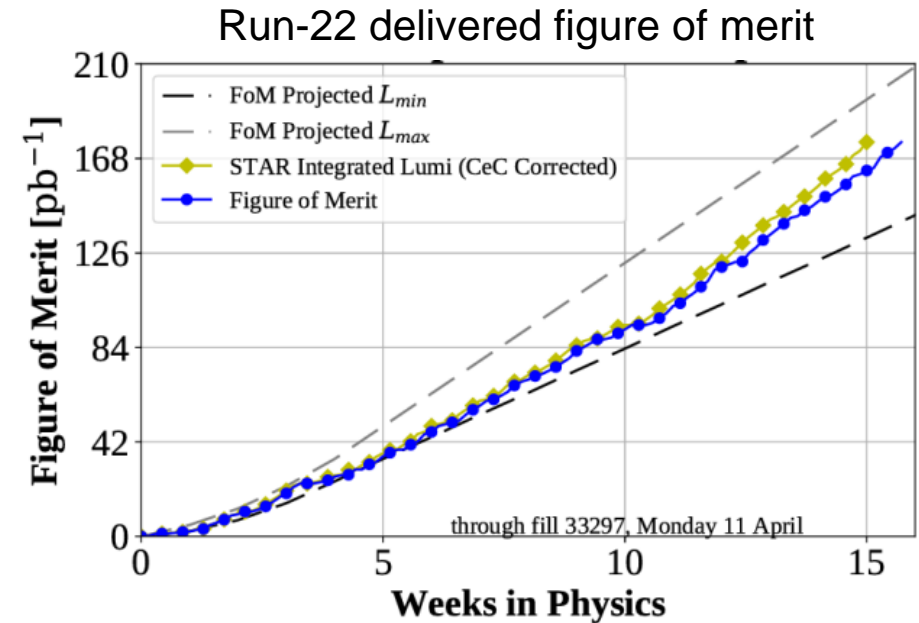
- sampled luminosity, L : 400 pb^{-1}
- sampled figure of merit, LP^2 : 121 pb^{-1} with $P = 55\%$

Schedule

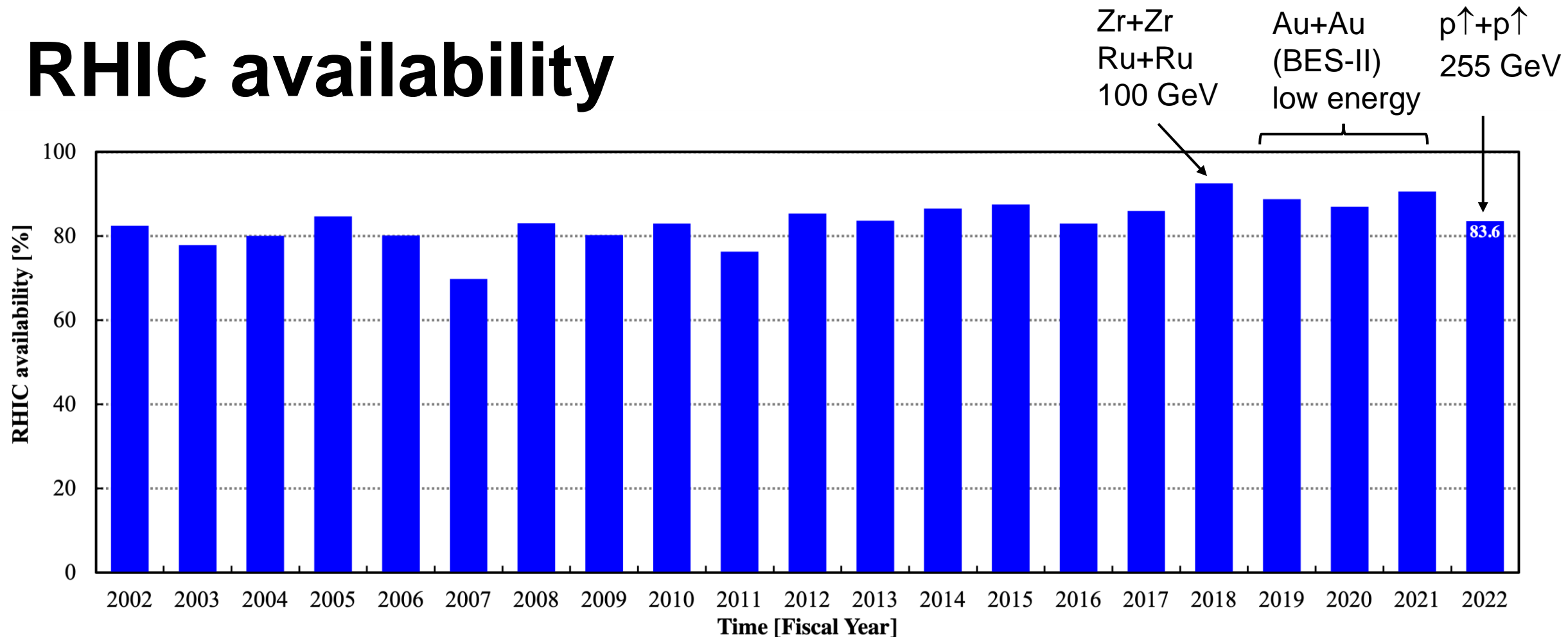
- final cooldown to 4K delayed by 13 days
- 14 day run extension granted by DOE Office of NP

Performance summary

- average store polarization, $\sim 50\%$ for both beams
run average: $\langle P_B \rangle = (50.0 \pm 0.2)\%$, $\langle P_Y \rangle = (49.5 \pm 0.2)\%$
last 60 stores: $\langle P_B \rangle = 54.1\%$, $\langle P_Y \rangle = 53.4\%$
 - two snake magnets damaged (power outage), operated as a partial snake
 - extended running with Westinghouse motor generator
 - achieved sampled figure of merit,
 LP^2 : 117.2 pb^{-1} (96.9%)
- luminosity consistent with previous full energy run
 - achieved sampled luminosity, L : 452 pb^{-1} (113%)



RHIC availability



Availability = beam time / scheduled beam time

(denominator excludes scheduled maintenance)

Availability goal: 85% (raised in FY20, from 82.5%)

83.6% in Run-22 - slightly shy of 85% goal, yet very good considering first full energy accelerator operations since 2017

Program Advisory Committee Comments and Recommendations relevant to C-AD

(22-23 June 2021)

The top overall priority in planning for these three runs is to commission the sPHENIX detector and to achieve its scientific program

CeC:

- The PAC recommends that BNL Management and CeC work together to ensure that the CeC beam use request can be accommodated as early as possible in Run 22 in order to allow for optimized STAR data taking.
- The PAC recommends that the BNL Management and the CeC project follow through in a timely fashion with the recommendations of the CeC review committee to establish the CeC technology for possible EIC application.

See V. Litvinenko's presentation

BNL Lab Management:

- The PAC recommends that BNL Management do everything possible to ensure a run sufficient for sPHENIX to accomplish its physics goals in Runs 23, 24 and 25.

Limited time to complete sPHENIX program, especially if runs are only 24 cryo-weeks/year.

Select compliments

Program Advisory Committee (22-23 June, 2021)

- “We repeat here our highest praise for BNL, C-AD, and STAR for an extraordinarily successful Run 21.”

DOE Site Visit (17 Nov, 2021)

- “You at Brookhaven have an embarrassment of riches ... shown that you have the talent and the tools to get it done...” (T. Hallman)

DOE NP Lab Managers Budget Briefing (16 Feb, 2022)

- “.. Congratulatory, what comes through is the fantastic work and things to be done... The accelerator team at C-AD continues to do everything to get every ounce of efficiency...” (T. Hallman)

Planning through end of RHIC operations / start of EIC construction

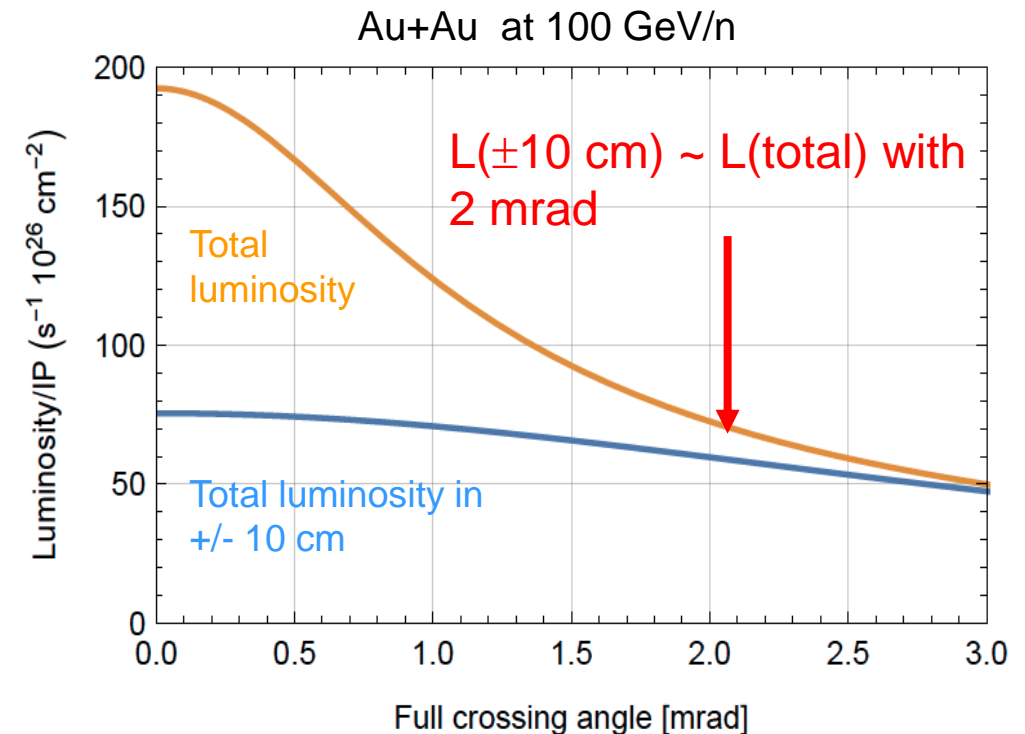
Run-23 through Run-25 with sPHENIX and STAR

Planned Operating Modes – all with 100 GeV/n beams

- Run-23 RHIC Run: Au + Au – run coordinator: Travis Shrey
- Run-24 RHIC Run: p↑ + p↑, p↑ + Au
- Run-25 RHIC Run: Au + Au

Maximizing useful luminosity with sPHENIX

- Use of 56 MHz SRF cavity (for increased longitudinal focusing)
- Small vertex (+/- 10 cm) with 2 mrad crossing angle
- Use of upgraded machine/experimental protection system (abort kicker relays+ faster detection of anomalies)
- New power supplies in IR8 for larger operating margin / smaller β^*)



Run-23 to Run-25 with sPHENIX and STAR

From draft BURs in preparation for NPP PAC next week

sPHENIX request

Table 1: Summary of the sPHENIX Beam Use Proposal for years 2023–2025, as requested in the charge. The values correspond to 24 cryo-week scenarios, while those in parentheses correspond to 28 cryo-week scenarios. The 10%-*str* values correspond to the modest streaming readout upgrade of the tracking detectors. Full details are provided in Chapter 4.

Year	Species	$\sqrt{s_{NN}}$ [GeV]	Cryo Weeks	Physics Weeks	Rec. Lum. $ z < 10$ cm	Samp. Lum. $ z < 10$ cm
2023	Au+Au	200	24 (28)	9 (13)	3.7 (5.7) nb ⁻¹	4.5 (6.9) nb ⁻¹
2024	$p^\uparrow p^\uparrow$	200	24 (28)	12 (16)	0.3 (0.4) pb ⁻¹ [5 kHz] 4.5 (6.2) pb ⁻¹ [10%- <i>str</i>]	45 (62) pb ⁻¹
2024	$p^\uparrow + Au$	200	–	5	0.003 pb ⁻¹ [5 kHz] 0.01 pb ⁻¹ [10%- <i>str</i>]	0.11 pb ⁻¹
2025	Au+Au	200	24 (28)	20.5 (24.5)	13 (15) nb ⁻¹	21 (25) nb ⁻¹

← will have to move DX magnets during Run-24 (~1 week)

STAR request

Table 1: Proposed Run-23 - Run-25 assuming 28 cryo-weeks of running every year, and 6 weeks set-up time to switch species in 2024. For $p+p$ and $p+Au$ sampled luminosities assume a “take all” trigger. For Au+Au we provide the requested event count for our minimum bias trigger, and the requested sampled luminosity from our a high- p_T trigger that covers all v_z .

$\sqrt{s_{NN}}$ (GeV)	Species	Number Events/ Sampled Luminosity	Year
200	Au+Au	20B / 40 nb ⁻¹	2023+2025
200	$p+p$	235 pb ⁻¹	2024
200	$p+Au$	1.3 pb ⁻¹	2024

Table 2: Proposed Run-23 - Run-25 assuming 24 cryo-weeks of running every year, and 6 weeks set-up time to switch species in 2024. For $p+p$ and $p+Au$ sampled luminosities assume a “take all” trigger. For Au+Au we provide the requested event count for our minimum bias trigger, and the requested sampled luminosity from our a high- p_T trigger that covers all v_z .

$\sqrt{s_{NN}}$ (GeV)	Species	Number Events/ Sampled Luminosity
200	Au+Au	17B / 34 nb ⁻¹
200	$p+p$	176 pb ⁻¹
200	$p+Au$	0.98 pb ⁻¹

Schedule (proposed) for RHIC with sPHENIX and STAR

Adapted from
projections by
B. Christie

(assumes 28 cryoweeks/year: “scenario 2” from 2022 Lab Manager Budget Briefing)

Year	RHIC operations (cryo)	Shutdown/maintenance
Run-23 Au+Au at 100 GeV	2/6/23 – 8/20/23	8/21/23 – 1/7/24 (20 weeks)
Run-24 p↑ + p↑, p↑ + Au at 100 GeV	1/8/24 – 7/21/24	7/22/24 – 12/8/24 (20 weeks)
Run-25 Au + Au at 100 GeV	12/9/24 – 6/29/25	6/30/25 end of RHIC programs start of EIC construction

Assumes end of RHIC Operations and start of EIC construction end of June, 2025
Actual schedule will depend on approved budgets (RHIC Ops and EIC)

25+ Year Upgrade Plan

Initiated in 2018 for RHIC, the injector complex with considerations for the EIC

Assessed annually based on need for

- performance upgrades
- upgrades of obsolete systems

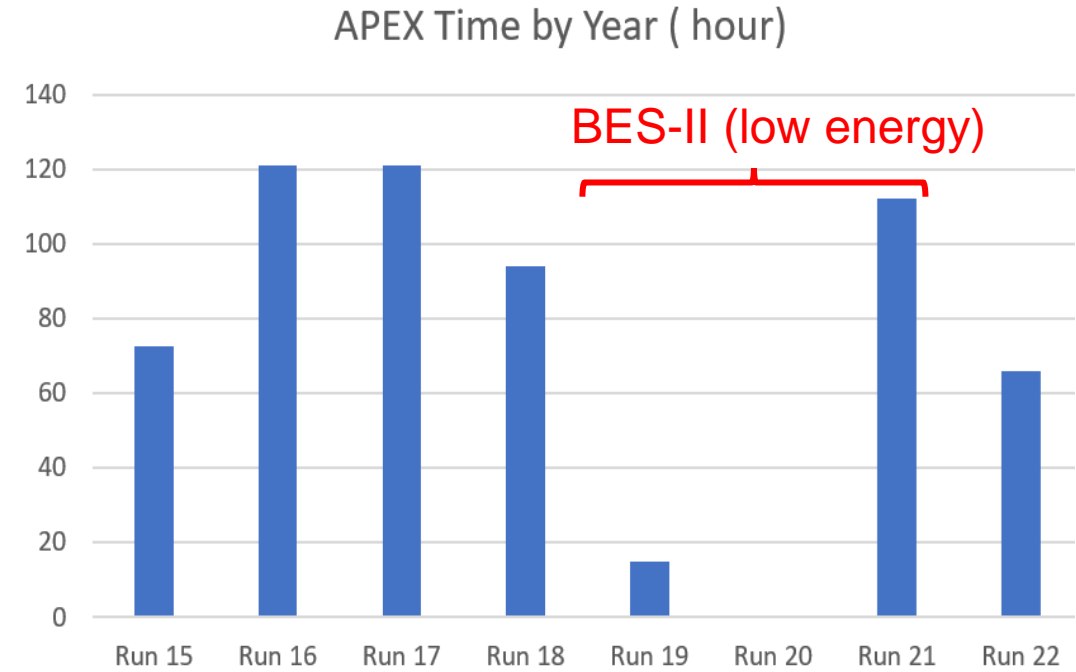
Assumed no further large performance upgrades of RHIC after LEReC until end of RHIC operations

Updated Upgrade Plan and Goals

- Maintain technical infrastructure
- Ensure hadron injector complex ready for EIC commissioning while also running for external users (e.g. NSRL and BLIP), possibly HEET
- Ensure that system upgrades satisfy both short-term injector and RHIC needs as well as longer-term EIC requirements
- Develop a near-term plan to allow new systems to be tested prior to the end of RHIC beam operations (mid-2025)

APEX overview (2015 – present)

APEX topics	APEX Time (h)	Percentage
E-lens related experiments	74.5	12.7%
Spin related experiments	107	18.2%
LEReC related experiments	99	16.9%
CeC PoP related experiments	21	3.6%
EIC related experiments	95	16.2%
56MHz Related experiments	16.5	2.8%
Low energy run preparation	34	5.8%
Others	139.5	23.8%
Total	586.5	100%



CeC
E-Lens
56 MHz
EIC

E-lens
Spin - energy scan, harmonic bumps, spin flipper
EIC - impedance measurements, IBS

LEReC – many including magnet cycling
EIC – coupling BTF, circumference lengthening and more

E-lens (for collimation)
LEReC

R&D Cooling
Machine Learning
EIC

EIC: general, Spin, and R&D Cooling

R&D Beam Cooling and High-Current Electron Beams

A. Fedotov
V. Litvinenko

Motivation: demonstrate stable long-term operation of electron beam sources
at ~ 100 mA current for
low-energy coolers (~ 20 MeV) or
high-energy strong hadron cooling, CeC (~150 MeV)

Theoretical and experimental studies in beam cooling and technologies underway.
Experimental R&D continues using both the LEReC and CeC facilities

Plans:

- LEReC – cooling studies using APEX (in FY23) with ions

- LEReC – high current studies in FY23 in parasitic mode (50 mA, demonstrated in 2022)
later studies require re-location of high-power beam dump

- CeC – demonstration of coherent electron cooling (parasitic mode and APEX)

- CeC – high current studies (with SRF gun)

New Facility Developments

High Energy Effects Test (HEET) Status and Plans

Scope

A dedicated radiation effects testing facility operated off the AGS capable of supplying

- Beams of protons and ions
- A wide range of beam energies (40 MV/n to 2000 MeV/n)

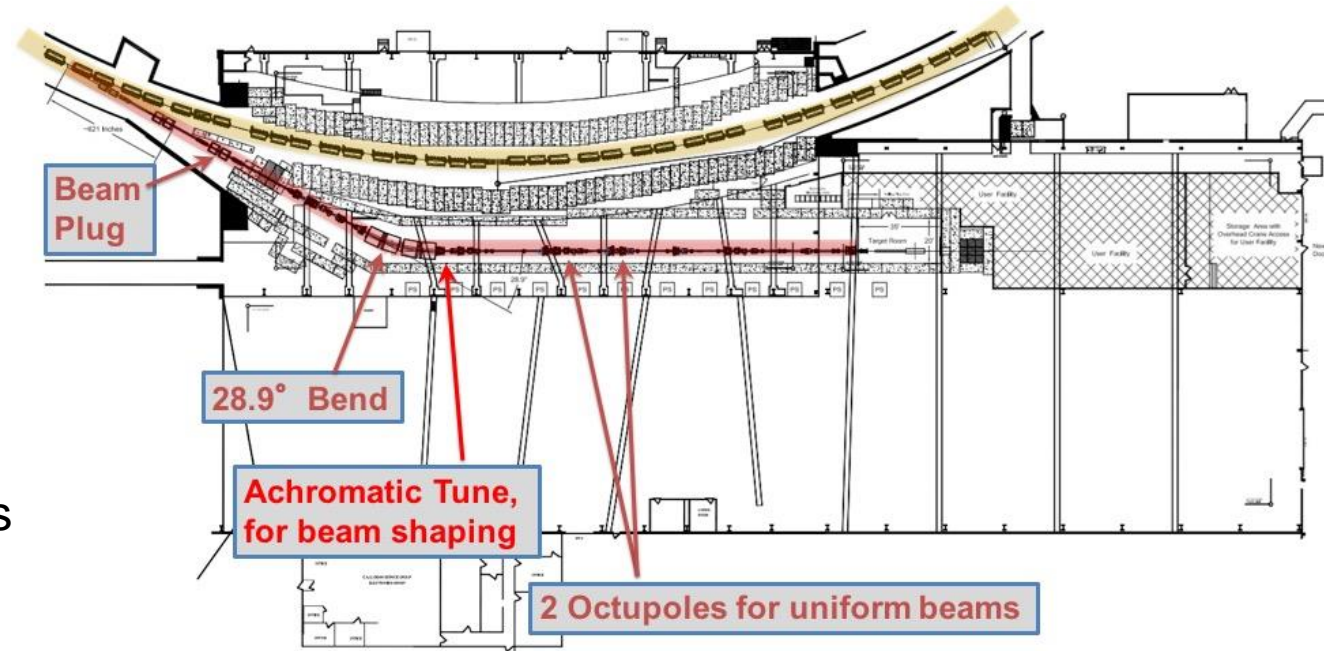
with ability to simulate Galactic Cosmic Ray spectra

Status

- Revising cost estimate and working on optics solutions
- Working with stakeholders to develop requirements (key performance parameters)

Schedule

Ready to start the HEET project in 2023



Expansion of Isotope Program: CLIP Status and Plans

D. Raparia
C. Cutler

Scope

- 600 MeV , 200 uA normal conducting Linac; Linac as injector at 200 MeV
- 60 MeV/u ($m/q < 2.3$), 200 uA, 10-60 MeV/u SC linac
- Four target stations and target processing facility

Status

- Pre-conceptual design of accelerators finished
- R&D items for the project are identified
- Target configuration for 600 MeV P under development
- Pre CDR document in preparation
- Cost estimate under progress

Schedule

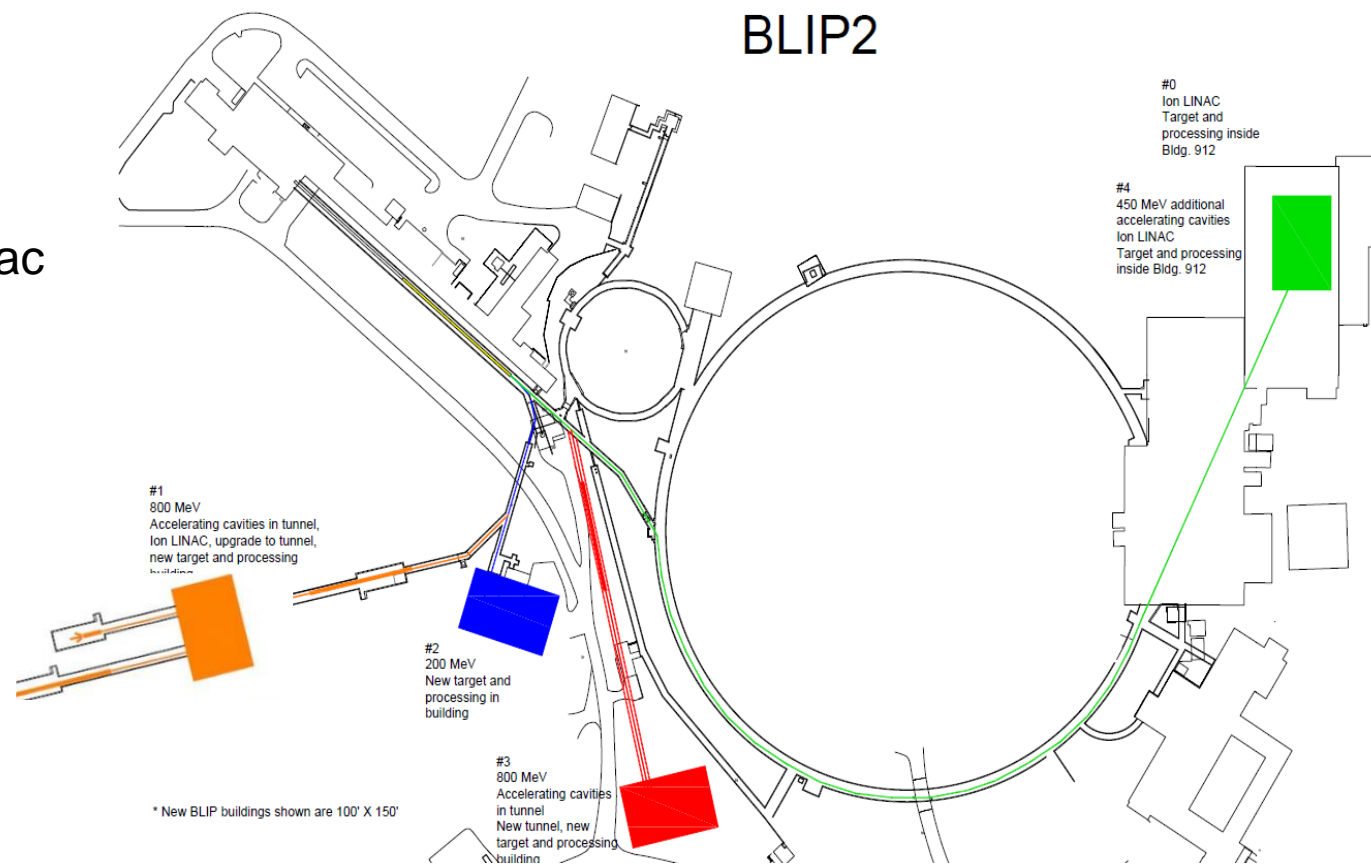
Director Review (TBD)

CD-0 FY 25

CD-1 FY 26

CD2/3 FY 28

CD-4 FY 33



Excellent progress on addressing DOE IP request for a major (not incremental) upgrade to isotope production program.

Safety and Accelerator Safety

Safety - Events since September 1, 2021

8 injuries to our co-workers (18 days DART)

1 instance of “illness while working on site” affecting 3 employees
(27 days of DART)

1 High Level Event

employee receives shock during dewar transfer (10/21/21)

4 Low Level Events

electrical work performed without LOTO in place (11/17/21)

improperly applied LOTO (12/22/21)

brush spring repair on Siemens generator (11/29/21)

potential worker exposure to live electrical power circuit (4/20/22)

No ASE Violations since September 2021

Accelerator Safety - Readiness Reviews and USIs

Readiness Reviews Planned

- AP Hot Cells (Isotope Program)
 - ARR: June 2022
- MIRP Cyclotron (Isotope Program)
 - IRR: July 2022
- Tandem Van de Graaff
 - ARR: August 2022 (?)
- sPHENIX
 - IRR: December 2022
 - ARR: January 2023
- Booster
 - IRR: February 2023 (Proposed)
 - ARR: April 2023 (Proposed)
- ATF
 - ARR: July 2023 (Proposed)
- LINAC
 - ARR: October 2024 (Proposed)
- AGS
 - ARR: September 2026 (Proposed)

Upcoming USI Reviews for Site Office (May 2022)

- MIRP New Targets
- sPHENIX Magnet Testing and Field Mapping

Many reviews required. Each and every review requires support from One and All to complete.

Reviews needed to execute our missions.

Summary

Summary

Run-22 RHIC Run – successful despite numerous challenges

- Resumed polarized proton operation at full energy (last operated in Run-17).
- Luminosity goal achieved (113%), slightly shy of figure-of-merit goal (96.9%) and accelerator availability goal (98.4%).

Run-23 through Run-25 with both sPHENIX and STAR

- Top priority: the new sPHENIX detector and completion of scientific program
- APEX continues to enable future experiments and further accelerator science
- R&D continues in beam cooling and high current electron beam generation
- EIC commissioning readiness will be ensured via 25-year upgrade plan

New Facilities - both HEET and CLIP developments progressing well

Safety - we must all be vigilant to protect ourselves and those around us